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Invariance of rest mass in a non-frame-equivalence reality

Once again we have a situation in which careful consideration of energy flows unearths an asymmetry where symmetry appears to be the order of the day. The difference is that here there's no need to resort to the new-found insight on the spun-light nature of material particles to prove the case: the peaceful coexistence of actual asymmetry and apparent symmetry is shown by reference to scientific findings sufficiently well-established to have merited Nobel awards.

That apparent symmetry is attested to by practical experience at sub-microscopic and astronomical levels: results from particle colliders around the world, space shots beyond the heliosphere to the regions between the stars, all confirm our understanding of the innate nature of *mass*. If we had that wrong, events such as the recent stunningly successful fly-past of Pluto just wouldn't have happened.

The question then is, given this asymmetry at the energy-flow level, whether the spun-light model supports the impression of symmetry at the level of particle acceleration. This is the level at which the apparent energy content of a particle has an effect for all practical purposes – the level at which laws of motion come into play. It's at this level that the notion of mass is relevant, including the idea that 'rest-mass' is the same (or appears to be so) in all reference frames.

Intuitively we'd expect that if energy-flow considerations show the perceived energy content in a moving frame to be γE_0, where E_0 is true rest-energy, then the perceived 'rest-mass' in that frame would be γm, where m is true rest-mass. If this were so then an increase in particle speed as perceived from the objectively static frame wouldn't give a corresponding (apparent) increase as viewed from the particle's own rest-frame – as all of the practical evidence, from space flights to supercolliders, appears to indicate that it does.

We know, though, that the asymmetry of spun-light physics *does* lead naturally to the symmetry of the Lorentz Transformation. So we can confidently use that transformation, and its resulting transformed velocities, as the toolkit for our investigations. This will lead us either to a contradiction or to confirmation that a spun-light reality does indeed produce effects as widely observed.

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For this exercise we'll look at the increase in speed of the same object as seen from the perspectives of both a static observer and an observer moving with the same velocity as the object before it changes speed. Using the transformation that's agreed by Relativity and spun-light physics to give the moving observer's view of the situation – objectively in the former case, subjectively in the latter – we'll see how the physics of the two perspectives match up.

We'll then take a look at how Relativity and spun-light physics differ, slightly but crucially, in their appraisal/explanation of this scenario. We'll need to look at how input energy translates into inherent 'energy of motion', from points of view of both static and moving observer, in each case.[4]

We can see this process in action in the following fairly simple example.

We'll consider an elementary particle – say an electron – moving at speed u in the laboratory frame; we'll take the laboratory to be in the objectively static universal rest frame. We'll then consider a high-energy photon emitted from a particle in the laboratory frame pursuing the electron along its line of motion. We'll see how Compton scattering of that photon works out from the perspective of both the lab frame and the initial 'rest-frame' of the electron.

Compton scattering (generally) involves a photon giving up some of its energy to a particle and bouncing off it with a reduced energy. In this exercise we're not interested in the energy left in the photon, as is usually the case, but in the energy transferred from the photon to the electron, giving it more speed. We'll work with a direct 'tail-on' impact, so that initial and final directions of both electron and photon are all in the same line with no scattering at an oblique angle.

Figure A2 over the page shows the photon impacting on the electron with initial energy E and scattering back along its original track (in the reverse direction) with reduced energy e. The rest mass of the electron in the lab frame is m.

Figure A3 shows the same incident from the perspective of the initial rest-frame of the electron. We'll refer to the 'rest mass' of the electron in this situation as m' and the initial and final energies of the photon from this perspective as E' and e' respectively. We'll look at the relationships between m and m', also E and E', and see what they can tell us about 'rest mass' in different frames of reference.

We will of course need to consider the situation in figure A3 from both the spun-light perspective on matter and the perspective of conventional Relativity. We'll find that, as we would expect, the conventional view is totally self-consistent and produces results in line with experimental observations. We'll also see how this could be down to mutually-compensating misperceptions, as revealed by insights from the spun-light understanding of material structure.

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4. Note that this exercise is wholly based on application of the Lorentz Transformation. It's therefore guaranteed that this mathematical process will translate a smooth physical process in a static frame into a corresponding smooth process in the moving frame. Put simply, if energy were applied incrementally giving a steady acceleration in the one, matching increments would give matching steady acceleration in the other.

Notes (If you're allergic to algebra, skip to the **bold type** three pages ahead!)

(1) Particle speeds u, v, w are fractions of full light speed, c, for compatibility of notation; so actual speeds are uc, vc, wc as referred to in momentum terms.

(2) γ_u, γ_v, γ_w are the standard Lorentz factors for motion at the above speeds.

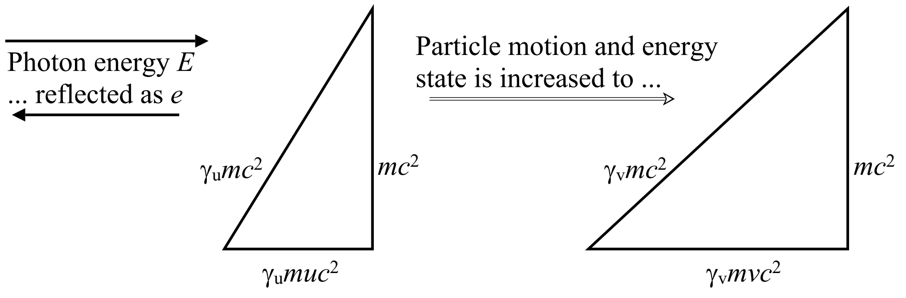

Fig. A2
Initial and final energy-momentum relation for moving particle as observed by a static observer in the laboratory frame: A photon emitted in the lab frame with energy E hits a particle moving at speed uc in the same direction, increasing the particle's speed to vc and reflecting the photon back along its original line of action with reduced energy e (Compton scattering).

From Fig. A2:

Conservation of energy: $E - e = (\gamma_v - \gamma_u)mc^2$

Conservation of momentum: $E/c + \gamma_u muc = \gamma_v mvc - e/c$

i.e.: $E + e = (v\gamma_v - u\gamma_u)mc^2$

Giving: $2E = mc^2[(v + 1)\gamma_v - (u + 1)\gamma_u]$ (1)

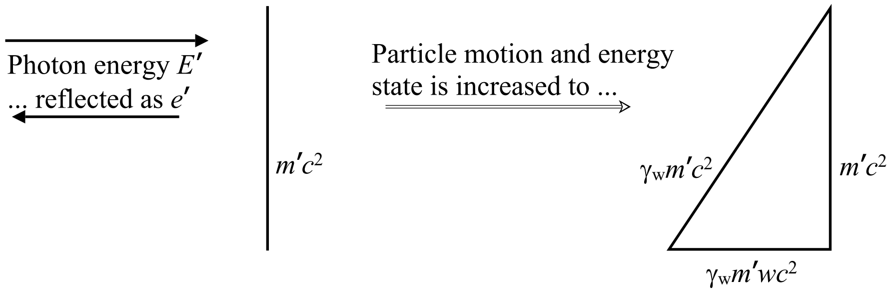

Fig. A3
Situation as in Fig. A2, but as seen by an observer moving with the particle at its initial speed uc. Particle is seen as initially at rest with mass m', hit by a photon with energy E' (m' and E' to be determined) which is reflected with energy e'. Particle appears to be given a speed wc (or w, as a fraction of c).

From Fig. A3:

Conservation of energy: $E' - e' = (\gamma_w - 1)m'c^2$

Conservation of momentum: $E'/c = \gamma_w m'wc - e'/c$

i.e.: $E' + e' = \gamma_w m'wc^2$

Giving: $2E' = m'c^2[(w + 1)\gamma_w - 1]$ (2)

Replacing w throughout the expression $(w + 1)\gamma_w$ [including in the term γ_w, equal to $1/\sqrt{(1 - w^2)}$] by the formula agreed by both Relativity and spun-light physics for such an apparent speed:

$$w = \frac{v - u}{1 - uv}$$ [footnote 5, following page]

gives us: $$(w + 1)\gamma_w - 1 = \frac{(v + 1)\gamma_v - (u + 1)\gamma_u}{\gamma_u(1 + u)}$$

So equation (2) becomes: $$2E' = \frac{m'c^2[(v + 1)\gamma_v - (u + 1)\gamma_u]}{\gamma_u(1 + u)} \quad (3)$$

Combining equations (1) and (3), we arrive at: $$E' = \frac{m'/m \times E}{\gamma_u(1+u)}$$

This can of course be written as: $$E' = \frac{m'}{m} \times \frac{E}{\gamma_u(1+u)} \quad (4)$$

If we accept the idea, widely supported by empirical evidence, that the apparent rest-mass of the electron in its own initial (moving) rest-frame is the same as its true rest-mass (when objectively static), this gives us: $m' = m$, so $m'/m = 1$.

We then have: $$E' = \frac{E}{\gamma_u(1+u)}$$

This is standard first-order and second-order Doppler shift for an emitter that's receding from the static receiver: FODS factor = $1/(1+u)$, SODS factor = $1/\gamma_u$. So this result for energy (as emitted from a moving atom) received by a static particle precisely fits the conventional (Special Relativity) view that the electron can be seen as static with the emitting atom moving away from it.

But how does that work for an objective view of the electron being the moving object and the emitting particle being objectively static? This surely changes the whole situation with regard to both FODS and SODS?

Well, here's where it gets interesting. Because FODS for a static emitter with a moving receiver heading away from it gives a multiplication factor of $(1-u)$, and the factor for SODS is inverted to become γ_u rather than $1/\gamma_u$ as in objective terms it's the moving receiver, not the static emitter, that's subject to time dilation.

So spun-light physics gives us: $E' = \gamma_u(1-u)E$ – which is equal to $\dfrac{E}{\gamma_u(1+u)}$!

In other words, the objective spun-light result matches the subjective SR result.

Let's just walk through that again, a little more slowly.

Energy is released from an emitter as a photon with frequency f, giving a time between successive wave-peaks $t = 1/f$, so a wavelength ct (where c is light speed).

As perceived from the rest-frame of the electron when moving at its initial speed uc, that photon will be subject to first- and second-order Doppler effects. Those effects will be evaluated differently from SR and spun-light perspectives – but the consequences of those two perspectives aren't as different as one may expect.

First Order Doppler Shift

If the photon is emitted from a moving source at speed uc and impacts on a static particle, which is how the situation is seen from the SR perspective in the electron's rest-frame, then the source moves a distance uct further away between wave-peak emissions. Time between wave-peak arrivals is thus $(ct + uct)/c$ for emission interval t, or $t(1 + u)$ – an increase by factor $(1 + u)$ compared with the emission interval. So arrival frequency is *decreased* by a factor $1/(1 + u)$.

However, if the source is static in absolute terms and the particle is moving away with speed uc (as seen from the spun-light perspective), the photon is pursuing the electron at relative speed $c - uc$. So time between arrival of successive peaks for wavelength ct is $ct/(c - uc)$, or $t/(1 - u)$, giving a change in arrival frequency by factor $(1 - u)$ – again a decrease, but in a slightly different form.

Second Order Doppler Shift

From the perspective of the electron's initial state of motion, SR sees the source as being time-dilated by factor $1/\gamma_u$, since the electron is seen as being in a valid state of rest and the source as being in motion relative to that rest-state. Arrival frequency of that photon will thus also be taken to be reduced by that same factor $1/\gamma_u$, a SODS effect.

However the spun-light view on this situation tells us that in fact it's the electron that's in motion relative to the absolute rest-state, so it's the electron that's subject to time dilation rather than the source. Since the electron's responses are slowed by the factor $1/\gamma_u$, it will experience the frequency of the photon as being *increased* by a factor γ_u.

If we consider FODS and SODS together, then from the SR perspective we get a combined Doppler effect with a factor of $1/[\gamma_u(1 + u)]$, whereas from the spun-light perspective we get a combined Doppler effect with a factor of $\gamma_u(1 - u)$.

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5. (from prev. page). The expression for the post-collision speed of the particle as seen from the particle's original rest-frame, w, can be derived quite simply from the Lorentz Transformation, which was shown in Chapter 5 to subjectively apply in the spun-light view of reality just as it's assumed to objectively apply in conventional Relativity.

There we found that $dx'/dt' = (dx/dt - v)/[1 - (v/c^2)dx/dt]$. If we simply replace v by uc (moving frame speed), dx/dt by vc (particle final speed in static frame) and dx'/dt' by wc (particle speed in moving frame) we get the equation used on the previous page.

Comparing the two composite Doppler effects

$1/\gamma_u = \sqrt{(1 - u^2)}$

So $1/[\gamma_u\,(1 + u)] = \sqrt{(1 - u^2)}\,/(1 + u)$ [Combined Doppler by SR]

Now: $$\frac{\sqrt{(1-u^2)}}{(1+u)} = \frac{\sqrt{(1-u^2)} \times \sqrt{(1-u^2)} \times (1-u)}{\sqrt{(1-u^2)} \times (1+u) \times (1-u)} = \frac{\cancel{(1-u^2)} \times (1-u)}{\sqrt{(1-u^2)} \times \cancel{(1-u^2)}}$$

Of course, $1/\sqrt{(1 - u^2)} = \gamma_u$

So we arrive at: $1/[\gamma_u\,(1 + u)] = \gamma_u\,(1 - u)$ [Combined Doppler by spun-light]

In other words, the Doppler effect envisaged by SR as applying in the electron's reference frame precisely matches the Doppler effect applicable in that frame as given by spun-light physics, for rather different reasons.

We've already seen, just two pages back, how the spun-light paradigm agrees with Special Relativity on the relationship between energy emitted in the static lab frame and the resulting increase in speed of a moving article as experienced in the initial 'rest-frame' of that particle; this result follows from application of the Lorentz Transformation, agreed by both models of reality to truly portray at least the apparent situation from the perspective of that moving frame.

That relationship links the (apparent) photon energy experienced in the moving frame to the photon energy released in the lab frame (Equation 4) – via the ratio between rest-mass m in the static lab frame and (apparent) rest-mass m' in the moving frame. Identification of FODS and SODS effects, mathematically equal in both cases, confirms that ratio to be 1 in each case.

In short: both Special Relativity and spun-light physics are fully consistent with the notion that the apparent rest-mass of a particle in motion is identical to the rest-mass of that particle when static (SR considering the terms 'in motion' and 'static' to be interchangeable, whilst spun-light physics shows them to be truly objectively different).

Only the latter of these two perspectives, however, is able to show at the same time how this apparent identity springs fully consistently from an asymmetric reality – one in which the energy content of a particle in motion, as viewed from that state of motion, is *not* the same as the energy content of that particle in a state of absolute rest, as viewed from that rest-state.

This finding could have significant implications for energy resources as well as for cosmic calculations of both dark matter and dark energy. It may also reveal new insights into conventional matter at all scales from an elementary particle to a cluster of galaxies.

Most significantly of all, it quite definitively overturns the principle of inertial frame symmetry – the foundation stone of conventional Relativity Theory – whilst at the same time being fully consistent with experimental findings that appear to confirm that principle.